THE RELATIVE ADSORPTION OF MIXTURES OF OXYGEN AND NITROGEN IN COCOANUT SHELL CHARCOAL[1]

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It is a well known fact that gases are adsorbed in charcoal with rates and in total amounts that vary in a manner closely related to the boiling temperatures of the gases. A mixture of gases may accordingly have its proportions entirely altered by adsorption. This is the principle of the method of Gehloff for the isolation of atmospheric neon.[2] Dewar has mentioned it as a convenient means of extracting a high percentage of oxygen from the air.[3] A quantitative knowledge of the manner in which the presence of one gas to saturation affects the adsorption of another is of great importance since these are the conditions of use under which charcoal has sprung into prominence in modern warfare.

The experiments herein described deal with the relative adsorption of mixtures of oxygen and nitrogen in varying proportions by a highly activated charcoal prepared in the manner described in a previous report by one of the writers. Relatively large amounts of charcoal are employed with respect to the quantity of gas used so that saturation is in all cases reached in the course of thirty minutes or so. The charcoal which weighed 6.5 grams when saturated with dry air at 20° and 750 mm. pressure was contained in Pyrex glass bulbs which could be outgassed by a diffusion pump. Outgassing was for four and a quarter hours at 582°C. After outgassing the tubes were immersed in liquid air of definite age and temperature. While immersed they were exposed to the given gas mixture contained in a constant volume of 975 cc. The initial pressure of the mixture was 73.95 cm. and observations were taken of it at intervals while the adsorption was going on and until it had ceased to fall. A barometer and McLeod gauge formed a part of the above mentioned volume for this purpose.

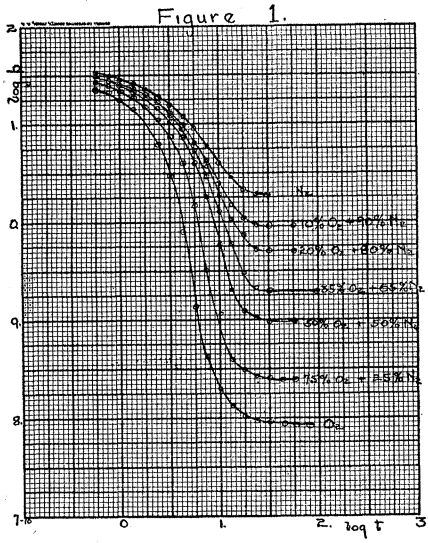
In figure 1 is given the data in graphical form where log p in cm. is plotted against log t in minutes after the adsorption began. The same sample always is included in this record, two others were used as controls. It is noted that the logarithm of the pressure reached by saturation is almost in a linear relation with the percentage of oxygen in the mixture.

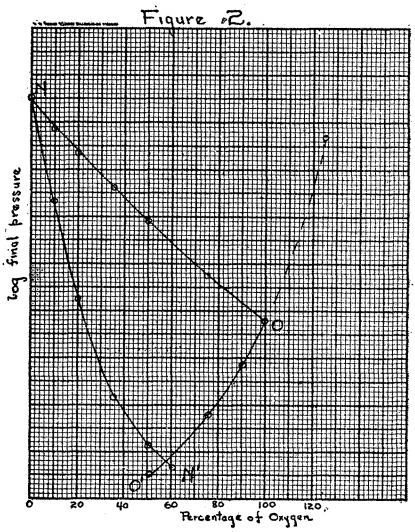
This is shown in figure 2 as the line NO. Here log final pressure is plotted against percentage of oxygen.

The other lines of this diagram NN' and OO' show the final pressures of amounts of pure nitrogen and pure oxygen equal to those existing in the mixture at corresponding values of abscissa but adsorbed separately.

It is important to note that in no case does the final pressure of a mixture fall as low as the sum of the final pressures of the two components when adsorbed separately. In other words, each component in the mixture hinders the adsorption of the other. This is not in agreement with an earlier paper by Bergter[4] who concludes that "in the range of pressure investigated the ability of charcoal to adsorb nitrogen must be increased by the presence of oxygen." Bergter's pressure range was entirely below 1 mm. and the discrepancy may be due to this difference of experimental conditions.

In the course of the work it became of importance to know if the final adsorption would be the same if a given amount of pure gas were adsorbed all at once as it would if half were adsorbed at one time and then the second half





admitted later. It was found that adsorption is much more complete in the second case, the quantitative pressures being as follows:

	Final pressure	*Log p*
a—Oxygen 100 per cent	0.00797	7.902–10
b—Oxygen 50 per cent, 50 per cent	0.00604	7.781–10
a—Nitrogen 100 per cent	1.86	0.270
b—Nitrogen 50 per cent, 50 per cent	0.649	9.812–10

In adsorbing equal parts oxygen and nitrogen it seems to be immaterial which is admitted first, the final pressure being within experimental limits the same.

Oxygen 50 per cent, Nitrogen 50 per cent	0.0451	8.654–10
Nitrogen 50 per cent, Oxygen 50 per cent	0.0481	8.682–10
Oxygen and nitrogen mixed each 50 per cent	0.0924	8.966–10

If a mixture of the two gases is adsorbed then as above the final pressure reached is considerably higher.

[1] This article is published with the approval of Major General William L. Siebert, Director Chemical Warfare Service, U. S. A.

[2] Gehloff, *Leipzig, Physik, Zs.*, **7**, 1913, (838).

[3] Dewar, *London, Proc. Roy. Soc.*, **74**, 1904, (122).

[4] Bergter, *Leipzig, Ann. Physik*, **37**, 1912, (606).

VARIATIONS, DUE TO HEAT TREATMENT, IN THE RATE OF ADSORPTION OF AIR BY COCOANUT SHELL CHARCOAL[1]

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This paper is an abstract of results of experiments most of which were performed prior to January 1918, but the publication of which has been withheld during the war.[1]

If charcoal contained in a bulb of glass or iron is heated to 600°C for about four hours and the gases which are freed pumped off into the low vacuum furnished by a mercury diffusion pump,[2] it is a well known fact that when the charcoal is then subsequently cooled to the temperature of liquid air it possesses a tremendous capacity for adsorbing gas, and will adsorb it at an extremely rapid rate. This adsorption power, however, has been found to be very different with different specimens of charcoal made from the same material, in this case cocoanut shell, and also to be very different when a single sample is used repeatedly. The magnitude of these differences is of no mean order but may be as large as the ratio of 10,000 : 1. It is shown in what follows that the heat treatment of the specimen during carbonization and also during successive 'outgassings' is a decisive factor in the control of the efficiency of the material as an adsorbent.

The experimental method was one of extreme simplicity. The shell was carbonized in an enclosed electric furnace having a vent for escape of gases and vapors. The temperature was indicated on a Leeds Northrup potential point resistance thermometer. The charcoal was then ground up to particles of from 1 to 3 mm. diameter and cleansed from all smaller fragments and dust. A definite weight (25.7 grams in most of the experiments, determined in dry air with which the charcoal was saturated) was sealed up in a tube of iron, quartz or Pyrex glass depending on the temperatures to be subsequently used. From this tube cocks communicated, (1) to the diffusion pump, and (2) to a fixed volume that could be filled with dry air at any desired pressure. This fixed volume included a McLeod gauge and a mercury barometer column so that the pressure in it could be read to within a few per cent over a range